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(71) APPLICANT: JOSEPH LUCAS (INDUSTRIES) LIMITED, residing in Great Britain.

(73) Owner: Idem (71).

(74) Agent: Regimbeau, Corre & Paiilet.

(54) Control apparatus for hydraulic transmission systems.

(72) Invention of:

(33) (32) (31) Convention priority:

The present invention concerns hydraulic control apparatuses for hydraulic automatic transmissions comprised of a piston-type hydraulic pump driven by a main motor, a piston-type hydraulic motor fed by hydraulic fluid by said pump, and a common component pierced by two ports by which said hydraulic fluid circulates between the pump and motor. This common component can be positioned so as to vary the respective stroke of the pistons of the pump and that of the pistons of the motor in order to vary the gear ratio of the pump shaft and the motor shaft; a control apparatus arranged so as to be able to move said common component supporting the ports with respect to variations in the speed of the main motor and variations in the pressure of the hydraulic fluid in those of the ports of said common component in which the pressure is the highest. Hereinafter, such a transmission system shall be referred to as the "type of described transmission".

The object of the present invention is the development of a hydraulic control apparatus in an embodiment that is particularly advantageous for the type of described transmission.

According to the present invention, the hydraulic control apparatus for the type of described transmission is comprised of: an auxiliary volumetric pump driven by the main motor with which the transmission is associated; conduits that link the discharge side of said auxiliary pump and the interior cavities of said supporting component of the ports; a valve linking said conduits and those of the two ports of said component in which the pressure is the lowest; a discharge valve through which the fluid passing through said port where the pressure is the lowest can exhaust; other conduits provided in the supporting component for the ports and through which the fluid passing through the port in which the pressure is the highest can exhaust, act upon the discharge valve, and move thereby to press against this valve from the action of the pressure of the fluid issuing

from the port in which the pressure is the lowest, the active surface of the discharge valve upon which the pressure bears is strongest being notably smaller than that upon which the lowest pressure bears, and this discharge valve provided so as to regulate the pressure in the port in which the pressure is the lowest relative to the pressure that exists in that in which the pressure is the highest; a piston and cylinder type master-slave apparatus, provided to move the supporting component of the ports so as to vary respectively the stroke of the pistons of the pump and those of the motor; and another valve that, when the discharge pressure of the auxiliary pump reaches a predetermined value, allows the fluid at the pressure existing in that of the ports in which the pressure is the lowest to enter through one of the ends of the cylinder of the master-slave apparatus and allows the fluid contained at the other end of said cylinder to exhaust from this end.

The description that follows and the appended drawings that are provided, especially as non-limiting examples, will aid in better understanding how the present invention can be developed.

Concerning the appended drawings:

- Figure 1 represents a pump-motor assembly comprising a transmission system conforming to the invention;

- Figure 2 is a view of the end of the assembly depicted in Figure 1;

- Figure 3 is a large scale section view along the longitudinal axis of the control apparatus comprising the master-slave apparatus associated with the transmission system depicted in Figure 1; and

- Figure 4 is a schematic representation of part of the control apparatus for the transmission system.

The transmission system represented is of the type described in the Patent Application filed in Great Britain under No. 4.412/68 in the name of the Applicant. This transmission system is comprised of a hydraulic pump 1

driven by a main motor 2 and a hydraulic motor 3 supplied with actuating fluid by pump 1 and that drives a gearbox output shaft 4. This pump and this motor are similar in construction and are of a type comprised of a rotating plate 5 coupled by multiple universal joints 6 to multiple pistons 7 spaced regularly on the same circumference and engaged with impeller 8. This impeller is pierced by a cylinder bore, each of which receives one of the said pistons, and the face of each impeller 8 furthest from the associated rotating plate is in contact with one of the faces of plate 10 supporting the ports through which the fluid can enter the cylinder bores that receive pistons 7 and pass from them. Pump 1 and motor 3 are mounted in same casing 11 comprised of two distinct parts separated from each other.

The port supporting plate 10 is common to the pump and to the motor, and the pump impeller and that of the motor apply themselves respectively to one or another of these faces. The arrangement of the assembly is such that any rotation of the port supporting plate 10 around its "X" axis, which is attached to the casing of the apparatus, causes a variation in the angle of the axis of the impellers relative to and respectively to the crankshaft and to the gearbox output shaft of the transmission system and, thereby, causes the stroke of the pistons of the pump and of the motor to vary and, consequently, also varies the speed ratio of the crankshaft and the drive shaft.

The control apparatus, which is the object of the present invention, is provided so as to be able to cause rotations of the port supporting plate 10, which, to this effect, and as can be seen in Figure 3, carries on its periphery an interrupted gear 12 that extends on a quadrant and meshes with a rack 13 fitted on a piston 14 of a piston and cylinder type of master-slave apparatus.

The position of the faces of the port supporting plate 10 against which press impellers 8 of the pump and that of the motor is such that plate 10 tends to move constantly in the direction that causes the stroke of the pump pistons to increase. But to resist this tendency,

two pistons 15 are provided in plate 10 that respectively act upon friction pads 16 that rub against the interior surface of casing 11, which, in this area, is eccentric relative to the axis around which the port supporting plate 10 pivots. Each of pistons 15 are comprised of two parts having different diameters and slide in appropriately shaped cylinder bores 17. These cylinder bores are supplied with fluid under pressure from any appropriate source, which may be constituted, for example, by plate ports 10 so as to create a friction reaction on the interior surface of casing 11. The axes of pistons 15 are eccentric relative to that of plate 10, as illustrated in Figure 3.

Figure 4 shows the position of ports 18 and 19 of plate 10, and it is assumed in the present description, which follows, that, when the transmission is in operation, the pressure in port 18 is greater than that acting in port 19. This high-pressure port 18 links the pressure port of the pump and the intake port of the motor when the transmission is in the forward gear position. However, it must be clearly understood that in the event of excessive revolutions per minute of the drive shaft, the conditions are inverted, and that port 19 then is subjected to greater pressure than to which port 18 is subjected.

Rotations of the port supporting plate 10 are controlled by master-slave piston 14 that slides in a cylinder 21, which is an integral part of casing 11 of the transmission, as shown in Figure 3.

This master-slave apparatus is a double action device comprised of two intake conduits 22 and 23, which open, respectively, at each of the ends of cylinder 21. On the end of this cylinder in which intake conduit 22 opens, an exhaust conduit 24 is provided through which the fluid contained in either end of the cylinder can exhaust in the direction of the transmission chamber in which the pressure is relatively lower, which, for example, could be an oil reservoir. However, the output of the fluid flowing through this conduit

24, is controlled by a rod 25 that pivots in the end wall of cylinder 21, through which conduits 22 and 24 pass and which are situated in an axial cylinder bore 26 of piston 14.

A lever 27, linked to a manual transmission control, is fixed at one end of rod 25 that passes out of cylinder 21. This end of rod 25, which pivots in the end wall of cylinder 21, has a circular groove 28 flanked by two circular seal grooves 29. Groove 28 is connected via conduit 31 to conduit 24. Rod 25, which is cylindrical, is pierced along its axis by a conduit 32 that connects a hole 33 that opens in groove 28 and a hole 34 that opens in a large, helicoidal groove 35 that ends on the shoulder formed by rod 25 near its free end.

Piston 14 is pierced by two longitudinal conduits 36 and 37 that are connected with its axial cylinder bore 26 by two transversal and diagonally opposed holes 38 and 39.

Helicoidal groove 35 forms a complete and relatively large coil that extends until the previously mentioned shoulder of rod 25. The movements of piston 14 relative to this rod are able to connect transversal holes 38 and 39 and helicoidal groove 35. When this groove 35 is connected with either of holes 38 and 39, the fluid contained in the end of corresponding cylinder 21 can exhaust through conduit 36 or 37, hole 34, conduit 32, hole 33, groove 28, conduit 31, and exhaust conduit 24. When the two transversal holes 38 and 39 are both connected to helicoidal groove 35, the pressures on the two faces of piston 14 become equal and stop its movement.

If one wishes to keep the transmission in the forward gear position at an intermediate gear ratio, lever 27 must be put into a position in which it is relocated relative to its position in Figures 3 and 4 at an angle of between 90° and 180°, the rotation of lever

27 causing that of rod 25. When the piston, moving itself because of the effect of the pressure applied in intake conduit 22, reaches a position in which helicoidal groove 35 is in contact with hole 38, intake conduit 22 comes into contact with exhaust conduit 24 via connection with conduit 32, and the forward movement of the pistons stops. The angular position of rod 25 thus determines the position at which the piston stops moving. Consequently, this angular position of rod 25 also determines that of the port supporting plate 10 and, consequently, the maximum gear ratio is reached.

A control unit 41 regulates the intake of fluid in either end of cylinder 21. This control unit is linked to cylinder 21 of the master-slave apparatus. Part of piston 14 of this apparatus can be seen in Figure 4.

It is desirable that the fluid that enters through the ends of cylinder 21 to regulate the gear ratio of the transmission system have a pressure that depends not only on the existing pressure of high-pressure port 18 of plate 10, but also on the rotation speed of the main motor. The position of the throttle valve of this main motor also determines, as will be explained below, the pressure of the fluid that enters the master-slave apparatus. Accelerator pedal 42 of the main motor is represented in Figure 4.

In order to provide fluid at the required pressure to intake conduits 22 and 23 of the master-slave apparatus, control unit 41 comprises a volumetric pump 43, which, in the represented embodiment, is a gear pump that intakes the fluid contained in an appropriate reservoir via a conduit 44, which, for example, could be an oil sump. Regarding pump 43 discharge, the back flowing fluid passes through a valve 45 whose position depends, as will be explained below, upon that of accelerator pedal 42. This fluid passes through a chamber 46 and flows via conduit 47, which opens in the free area delimited

by casing 11 surrounding the port supporting plate 10. This plate is pierced on its periphery by a hole 48 through which the fluid contained in the said free space can enter and which is connected to low-pressure port 19 via a manually controlled spring-loaded return valve 49 situated in cylinder 51, which also closes another spring-loaded return valve 52. The fluid that arrives via conduit 48 is thus able to reach the other port 18 in the event that this port should reach a pressure less than that present in port 19.

The port supporting plate 10 forms, between ports 18 and 19, a stepped radial bore 53 whose end with the greatest diameter is connected to a cylinder 54, which itself is connected to low-pressure port 19 via conduit 55. Cylinder 54 closes a two-way directional control valve 56 and its end positioned against that in which conduit 57 opens. This valve 56 ensures, in the position in which it is illustrated, that only low-pressure valve 19 can connect to the end with the greatest diameter of stepped bore 53. However, if the pressure in port 19 becomes greater than that in port 18, this valve changes position so as to ensure that it is always fluid under low pressure that acts in the end of stepped bore 53 with the largest diameter.

In this bore 53, a stress-relief valve 58 is situated that forms steps corresponding to those of this bore. A spring 59 presses constantly against a central annular boss 61 carried on the end with the largest diameter of valve 58 such that this boss has the tendency to bear against an associated seat formed by the bottom wall of bore 53. From the action of spring 59, discharge valve 58 can move so that its annular boss comes to act against the said seat, which has the effect of impeding the fluid from entering conduit 62 piercing the axis of valve 58.

Stepped bore 53 and conduit

62 open into a central cavity 63 of plate 10, which is connected to a low-pressure chamber from which the lubrication circuit of the transmission system departs.

The step of bore 53 that is closest to its end with the smallest diameter connects to high-pressure port 18 via conduit 64, and the adjacent step of this bore connects to port 19 by another conduit 65.

When the transmission is in operation, the fluid returned by pump 43 passes through valve 45 and, via conduit 47, discharges itself into the free space delimited by casing 11 surrounding plate 10. This fluid then circulates in hole 48 and enters low-pressure port 19. The pressure of the fluid in this port bears against the end with the largest diameter of discharge valve 58 and tends to move this valve so that its annular boss 61 disengages from the bottom wall of stepped bore 53 despite the resistance brought to bear by spring 59. When valve 58 is thus moved, the fluid coming from low-pressure port 19 can exhaust via conduit 62 in central cavity 63 of plate 10 from which it evacuates in the direction of the previously mentioned low-pressure chamber of the transmission system.

Nevertheless, the movement of the opening of discharge valve 58 is not only maintained by spring 59 but also by the action of the high-pressure fluid located in port 18 and which acts via conduit 64 upon the appropriate position of the this valve. Consequently, the pressure present in port 19 depends on that present in high-pressure port 18. The action of the fluid located in the low-pressure port and that is transferred to valve 58 via conduit 65 is negligible, as the surfaces upon which the high pressure and low pressure respectively bear are very different from each other, as can be seen in Figure 4.

The pressure in the low-pressure port is consequently equal to that present in the free space

delimited by casing 11 surrounding the port supporting plate 10, which is that present in conduit 47. This conduit 47 comprises a connection 66 forming a throttle and by which the fluid can flow through conduit 67, which is connected to intake conduit 23 located at one end of cylinder 21 of the master-slave apparatus. Chamber 46, which is traversed by the fluid issuing from pump 43 and which flows in the direction of conduit 47, also comprises an outlet port forming a throttle 68a through which the fluid can flow into another conduit 68, which itself is connected to intake conduit 22 located on the other end of cylinder 21 of the master-slave apparatus.

Control unit 41 comprises another conduit 69 that is connected to exhaust conduit 24 of the master-slave apparatus.

In chamber 46, a piston 71 moves, the rod of which forms a valve lid 72 and upon which a spring 73 bears that tends to constantly return it toward a position in which valve lid 72 allows the fluid to exhaust via throttle 68a, which is connected to chamber 46 and conduit 67 via a short conduit 74.

Piston 71 is placed so as to be subject to the pressures applied respectively upstream and downstream of valve 45. When the rotation speed of the main motor is sufficient to create a predetermined drop in pressure in valve 45, piston 71 moves so as to interrupt the connection between conduits 67 and 68, which are connected to each other via short conduit 74.

The value of the drop in pressure that causes piston 71 to move depends, however, on the position of valve 45, which depends on the position of accelerator pedal 42, as previously indicated.

Conduits 68 and 69 are connected to cylinder bore 75 in which a spool 76 slides. This spool 76 exits via one of the ends

from control unit 41, and its position is adjustable by means of a rod link not shown. Spool 76 has a peripheral groove 77 with which two conduits 68 and 69 are in contact when the spool is in its position as represented and which is in constant contact with conduit 78, which opens in a chamber 79 of control unit 41 in which the pressure is relatively low.

Between conduits 67 and 68, a conduit 81 is provided, which is normally closed by a valve lid 82 comprised of piston rod 83 equipped with a return spring 84 and which is subject on the face opposite of that upon which the spring is acting to the pressure present in conduit 47, and, when this pressure exceeds a predetermined value, piston 83 disengages lid 82 at the end of conduit 81 and thereby connects conduits 67 and 68. The other face of piston 83 is in contact with suction conduit 44 of pump 43 via a conduit 85 arranged in control unit 41. Pump 43 is also equipped with a discharge valve 86 situated in conduit 87, which diverts the fluid causing it to by-pass pump 43 if the pressure on the discharge side of this pump exceeds a predetermined value.

On the downstream side of valve 45, a conduit 88 is provided through which the pressure of the fluid can be applied to cylinder spool 89 upon which the return spring acts. This spring 91 presses its end against mobile boss 92, whose position is determined by lever 93 and whose own position depends on that of accelerator pedal 42. The movement of spool 89, despite opposing force from its spring 91, a force that itself depends on the position of accelerator pedal 42, allows the fluid to flow via conduit 88 into conduit 94. This conduit 94 is in contact with one of the ends of cylinder 95 in which a piston 96 slides and which carries a rod 97. This rod 97 supports a pivot arm 98, which creates a fulcrum and which is a part of the link rod connecting accelerator pedal 42 and the throttle valve of the main motor

associated with the transmission system. One sees, therefore, that the pressure present in conduit 88, which is the same as that present in conduit 47 and which consequently depends on the pressure present in high-pressure port 18, is used to determine the position of the fulcrum of the link rod of the throttle valve. This has the effect of limiting the opening of this throttle valve if the pressure in conduit 88 exceeds a predetermined value.

Accelerator pedal 42 is linked to a stem 101 equipped with a joint ball 102. This joint ball rolls in an inclined slot 103 supported by an arm 104, which itself is connected by a link 105 to valve 45. The position of this arm 104 and, consequently, the inclination of slot 103 relative to the movements of stem 101 depends on the position of a pushrod 106 connected to arm 104, which is constantly repelled by a return spring 107 and which carries on its end a joint ball 108 that rolls in a groove with a rounded bottom machined in the lateral surface of piston 14 of the master-slave apparatus.

When the transmission is in operation, to permit decreasing the reduction ratio of the gears in order to increase the speed of the associated vehicle, or other apparatus, without increasing the speed of the main motor, the assembly is equipped so that the port supporting plate 10 can be moved by rotation in a counter-clockwise direction as indicated by arrow 109 of Figure 3. To obtain such rotation, it is necessary to permit the fluid to enter cylinder 21 via intake conduit 22 and the fluid contained in the other end of the cylinder to exhaust. Therefore, cylinder spool 76 is moved in direction to the right as represented in Figure 4 so that it is located in the position indicated by the dotted line F, a position that allows it to interrupt the connection between conduit 68 and its groove 77 without interrupting the existing connection between conduit 69 and said groove 77.

Because conduit 68 is connected to intake conduit 22 and conduit 69 is connected to exhaust conduit 24, the fluid

can enter the end of cylinder 21 and cause piston 14 to move, which consequently causes the port supporting plate 10 to turn in the direction indicated by arrow 109. Nevertheless, this rotating movement cannot be produced unless piston 14 is in a position in which the fluid can exhaust via longitudinal conduit 37, rod 25, exhaust conduit 24, and conduit 69.

Nevertheless, the flow of fluid via conduit 68, and not via conduit 67, cannot occur unless the difference in pressures acting upon piston 71 is sufficient to interrupt the connection between conduits 67 and 68 by the action of valve lid 72. Because the fluid can exhaust from cylinder 21 via longitudinal conduit 37, the pressure in intake conduit 22 is greater than that present in intake conduit 23 and, consequently, the pressure is greater in conduit 68 than in conduit 67. The fluid can flow in conduit 68 via throttle 68a.

If one wants to increase the gear ratio of the transmission, piston 14 must be moved in the opposite direction. To do so, rod 25 must be turned so as to cause a connection between its helicoidal groove 35 and longitudinal conduit 36 of piston 14.

If one wants to put the transmission into reverse, cylinder spool 76 must moved to the left beyond its neutral position N in which it is represented and put into position R, which interrupts the connection between conduit 69 and low-pressure chamber 79 of control unit 41. This movement does not interrupt the connection between conduit 68 and said chamber 79.

When accelerator pedal 42 is in the position that closes the throttle valve, the drop in pressure in valve 45 becomes too weak to be able to move piston 71 because the motor slows, but when the operator of the vehicle causes the throttle valve to increase the rotating speed of the motor, valve 45 moves and thus creates

a drop in pressure sufficient to cause piston 71 to move and thereby interrupt the connection between conduits 67 and 68 reconnected via short conduit 74. The pressure in conduit 67 then becomes stronger than that present in conduit 68 because the latter is connected to low-pressure chamber 79 via groove 77, and piston 14 of the master-slave apparatus moves in the direction that causes an increase in the speed ratios of the drive shaft and the transmission crankshaft, because it causes the port supporting plate 10 to turn in the direction opposite of that indicated by arrow 109.

Volumetric pump 43 provides the necessary backup fluid to ports 18 and 19 to compensate for leaks that can occur via these ports when the transmission is in operation.

The pressure applied in the master-slave apparatus is thus dependent on the speed of the main motor, which is determined by the pressure downstream of pump 43 and by the pressure present in high-pressure port 18, as well as by the position of the throttle valve via valve 45.

Of course, the present invention is not limited to the embodiment described herein and can be extended to all variations conforming to its principles.

CLAIMS

1°) - A hydraulic control apparatus for transmission systems wherein are included: an auxiliary volumetric pump driven by a main motor with which the transmission is associated; conduits that link the discharge side of said auxiliary pump and the cavities of a supporting component for the ports that belong to the said transmission; a valve linking said conduits and that of the two ports of said component in which the pressure is the lowest; a discharge valve through which a fluid passing through the said port in which the pressure is the lowest can exhaust; other conduits provided in the port supporting component and through which the fluid through the port in which the pressure is the greatest can exhaust and come to act upon the discharge valve and tend thereby to oppose the opening of this valve by the action of the pressure of the fluid coming from the port in which the pressure is the lowest, the active surface of the discharge valve upon which the highest pressure acts being notably smaller than that upon which the low pressure acts, and this discharge valve being equipped so as to regulate the pressure in the port in which the pressure is the lowest relative to the pressure present in that in which the pressure is the strongest; a piston and cylinder type master-slave apparatus, provided to move the port supporting component so as to vary the respective strokes of the pistons of the pump and of the motor, and another valve that, when the discharge pressure of the auxiliary pump reaches a predetermined value, allows the fluid at the pressure present in the port in which the pressure is the lowest to enter one of the ends of the cylinder of the master-slave apparatus and the fluid contained in the other end of the said cylinder to exhaust out of this end.

2°) - A control apparatus according to Claim 1, wherein a manual control valve is situated in the said port supporting component, this valve being equipped so as to determine which of the two ports

of the said component is at greater pressure and to allow the fluid to flow via the discharge valve out of the port of these two ports in which the pressure is the lowest; the output of this flow through the said discharge valve being determined by the position of this valve in the port supporting component with respect to a seat formed by this component, and the seat creating a closing element for said valve.

3°) - A control apparatus according to Claim 1 and 2, wherein this port supporting component closes the said valves, one of which is manual and through which the pressure existing in the port in which the pressure is the lowest is applied in the said conduits.

4°) - A control apparatus according to one of the preceding claims, wherein the piston of the master-slave apparatus carries a rack that meshes with the teeth of the port supporting component, the movements of the piston thereby causing angular movements of the port supporting component.

5°) - A control apparatus according to one of the preceding claims, wherein the master-slave apparatus comprises a rod capable of turning around its axis and traversing the piston, this piston and this rod being equipped with holes by which the angular position of the rod on its axis relative to the piston determines the amplitude of the movement allowed for this piston in the cylinder from the action of the fluid.

6°) - A control apparatus according to Claim 5, wherein the hole carried by the rod is constituted by a large helicoidal groove that can be connected to conduits opening in the axial cylinder bores of the piston in which the said rod is engaged, the angular position of this rod thus determining the position of the piston in the axial direction for which the said connection is established.

7°) - A control apparatus according to one of the preceding claims, wherein a manual control valve is provided that, when in a certain position, allows fluid backed up by the

auxiliary pump to enter one of the ends of the master-slave cylinder and the fluid located at the other end of this cylinder to exhaust from it and that, when it is in another position, allows the fluid to enter the said other end of the cylinder and to exhaust from the opposite end.

8°) - A control apparatus according to one of the preceding claims, wherein another valve is provided in the conduits that regulates the passing fluid, the position of this other valve being determined by the position of a lever that acts upon the throttle valve and permits regulation of the rotating speed of the main motor to which the transmission system is coupled.

9°) - A control apparatus according to Claim 8, wherein the said valve is linked to a mechanism that makes it possible to vary the extent of its opening relative to the extent of the opening of the throttle valve of the main motor and according to the position of the master-slave apparatus in its cylinder.

10°) - A control apparatus according to Claim 8, wherein the said lever controlling the throttle valve pivots on a supporting element that is linked to an apparatus that acts relative to the pressure of the fluid in the said conduits and thereby causes the position of the said supporting element to vary.

11°) - A hydraulic transmission system wherein a control apparatus is equipped comprising: an auxiliary volumetric pump driven by the main motor with which the transmission is associated; conduits that link the discharge side of said auxiliary pump and the cavities of said supporting component of the ports belonging to the said transmission; a valve linking said conduits and the port of the two ports of said component in which the pressure is the lowest; a discharge valve through which fluid passing through the said port in which the pressure is the lowest can exhaust, and other conduits provided in the port supporting component

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and through which the fluid passing through the port in which the pressure is the highest can exhaust, coming to act upon the discharge valve and move thereby to impede the opening of this valve from the action of the pressure of the fluid issuing from the port in which the pressure is the lowest, the active surface of the discharge valve upon which the pressure bears is strongest being notably smaller than that upon which the lowest pressure bears, and this discharge valve provided so as to regulate the pressure in the port in which the pressure is the lowest relative to the pressure that exists in that in which the pressure is the highest; a piston and cylinder type master-slave apparatus, provided so as to move the supporting component of the ports so as to vary respectively the strokes of the pistons of the pump and those of the motor; and, another valve that, when the discharge pressure of the auxiliary pump reaches a predetermined value, allows the fluid at the pressure existing in that of the ports in which the pressure is the lowest to enter through one of the ends of the cylinder of the master-slave apparatus and allows the fluid contained at the other end of the said cylinder to exhaust from this end.

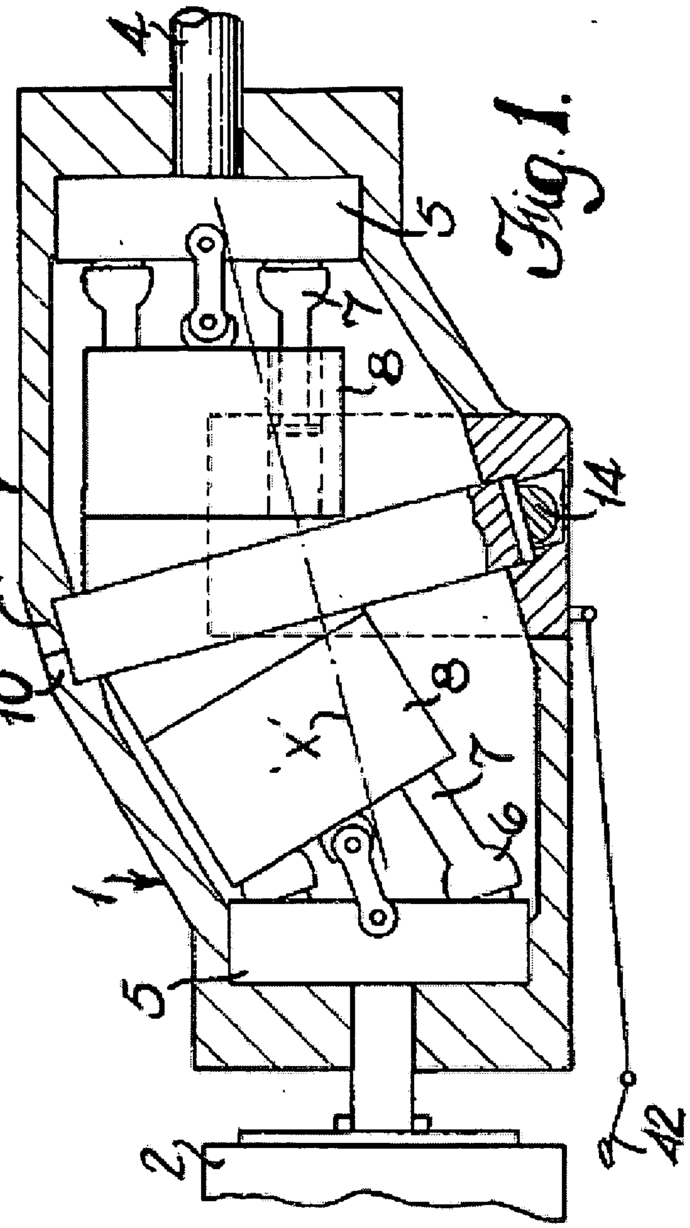

Fig. 1.

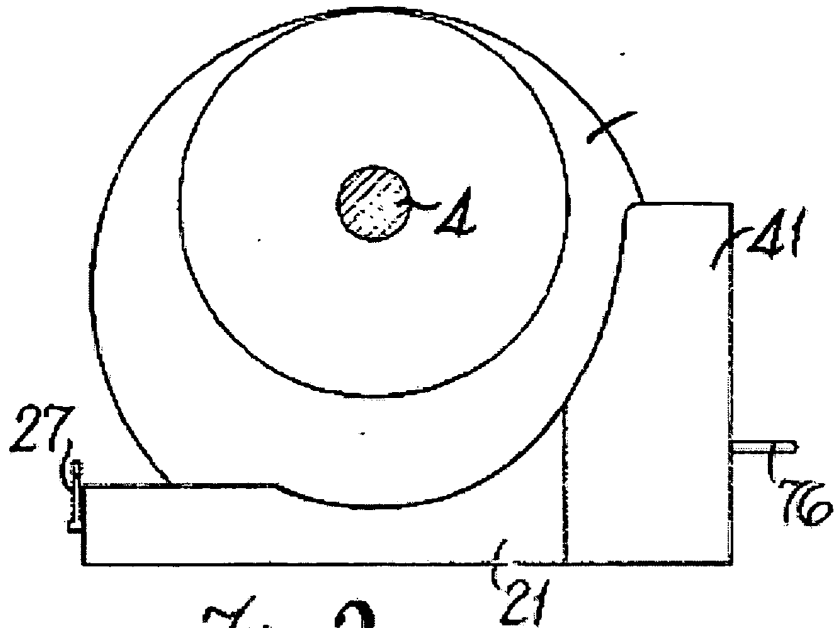

Fig. 2.

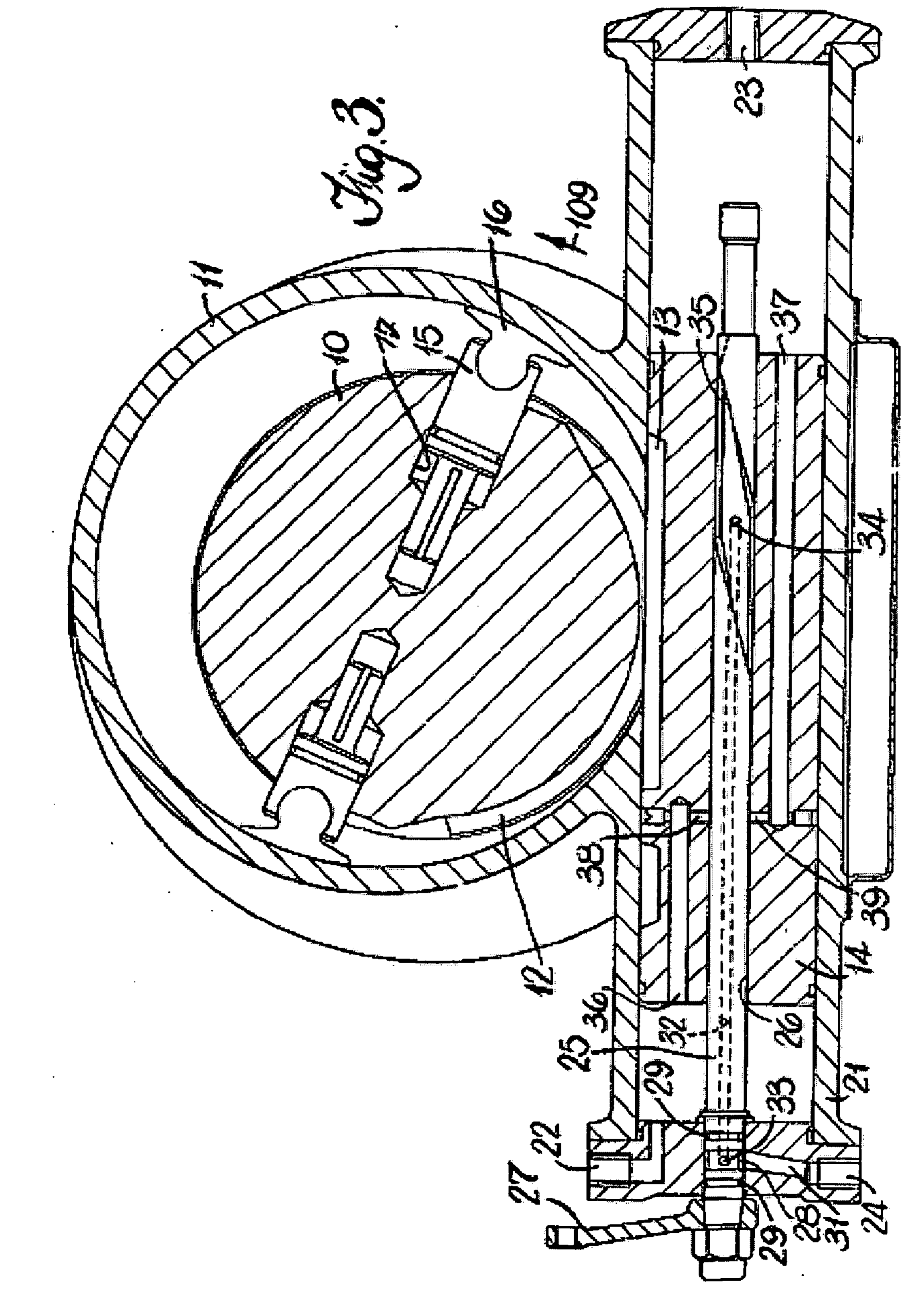
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Fig. 3.

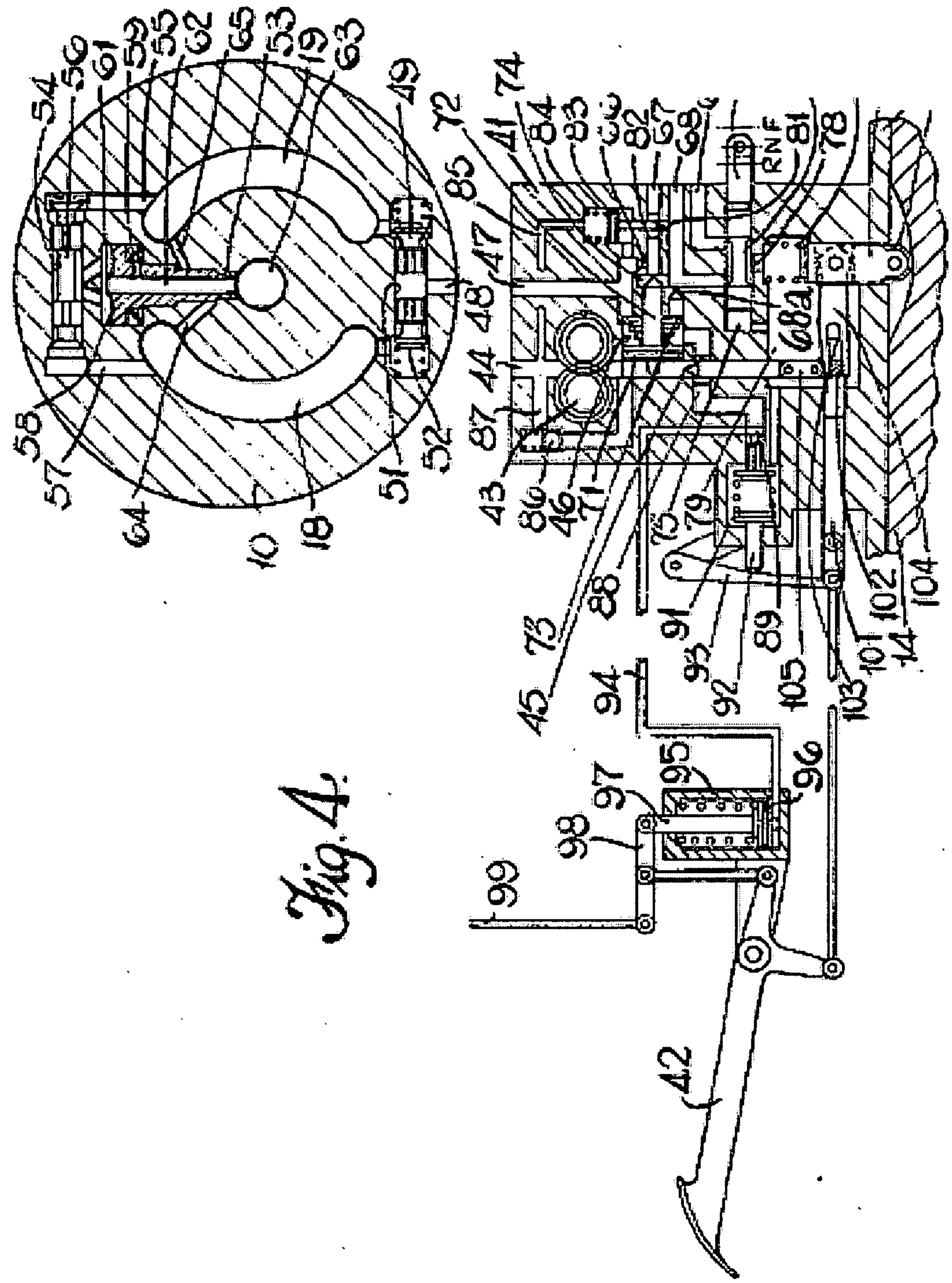

Fig. 4.